

## **MARS GLOBAL SURVEYOR**

# **Contingency Mapping Orbits Status**

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## GOALS, ASSUMPTIONS

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- CONTINGENCY MAPPING ORBIT PLANNING
  - DEVELOP STRATEGY TO COPE WITH OFF-NOMINAL MAPPING ORBIT
    - AEROBRAKING PROVIDES 1250 M/S VELOCITY CHANGE NEEDED TO GET FROM INITIAL CAPTURE ORBIT TO MAPPING ORBIT - SIGNIFICANT PROBLEMS WOULD RESULT IN HIGH ALTITUDE ORBITS
  - MORE A DECISION PROCESS THAN A DESIGN PROBLEM
    - FUEL FOR ORBIT CHANGES VERY LIMITED, RESTRICTING TRADE SPACE
      - CURRENT  $\Delta V$  BUDGET INCLUDES 45 M/S FOR CONTINGENCIES, 50 M/S FOR WALKOUT
      - RANGE OF ALTERNATE ACCESSIBLE ORBIT ENERGIES (SEMIMAJOR AXES) IS SMALL
- CASES CONSIDERED FOR MORE STUDY
  - AEROBRAKING TERMINATION AT HIGH ALTITUDE
  - AEROBRAKING DELAY CAUSING DRIFT BEYOND 2 P.M. NODE
- OTHER CASES?

## AEROBRAKING TERMINATION AT HIGH ALTITUDE

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- ASSUME EARLY END OF AEROBRAKING - APOAPSIS  $> 417$  KM
  - DUE TO SOME PROBLEM/FAILURE, LITTLE OR NO WARNING
- DESIRABLE ALTERNATE ORBITS TO LOOK FOR
  - ORBIT ALTITUDES BELOW 500 KM
  - DAYLIGHT PERIAPSIS, SUN-SYNCHRONOUS BEST
  - REPEATING GROUNDTRACK
- DECISION FLOW
  - ABX MANEUVER PERFORMED RAISING PERIGEE TO NOMINAL 345 KM
    - ELLIPTICAL ORBIT, LOW PERIAPSIS PREFERRED OVER HIGH CIRCULAR ORBIT
    - EARLIER ABX SAVES  $\Delta V$  ALREADY BUDGETED
  - SUN-SYNCHRONOUS ORBIT FEASIBLE?
    - INCLINATION  $i$  INCREASES WITH SEMIMAJOR AXIS  $a$ , REQUIRING PLANE CHANGE FROM NOMINAL MOI VALUE  $i = 92.86^\circ$
    - LIMITING ALTITUDE IS LOW - 345 X 1050 KM ORBIT NEEDS 45 M/S, 345 X 1925 KM ORBIT NEEDS 100 M/S
  - FROZEN ORBIT NOT POSSIBLE - ECCENTRICITY  $e$  TOO HIGH

## AEROBRAKING TERMINATION AT HIGH ALTITUDE

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- DECISION FLOW/ (continued)
  - NEARBY REPEAT ORBITS SIMILAR TO BASELINE?
    - BASELINE  $Q = 12 \text{ }^{317}_{550}$  ORBITS/DAY
      - NEAR REPEAT IN 7 AND 26 DAYS, 550 DAY SUPERCYCLE
    - $Q = 11 \text{ }^{317}_{550}$  HAS IDENTICAL REPEAT PATTERN, THOUGH GROUND TRACK SPACINGS SCALED UP BY RATIO ( $Q_{\text{BASELINE}} / Q$ )
      - 11 SUCH Q VALUES UP TO APOAPSIS ALTITUDE OF 23,000 KM
      - Q VALUES WHOSE REPEAT PATTERN IS A MIRROR IMAGE EXIST ON OPPOSITE SIDE OF  $1/2$ , E.G.  $4/7$  AND  $3/7$ , PROVIDING ADDITIONAL CHOICES. FOR BASELINE ORBIT THE VALUE IS  $233/550$  AND IS AT HIGHER ALTITUDE
  - IF CAUGHT BETWEEN TWO  $^{317}_{550}$  ALTITUDES, E.G. 4500 AND 5850 KM, CAN WE REACH ONE OF THEM?
    - REQUIRES 45-75 M/S TO GO TO NEXT (LOWER) ALTITUDE, LESS TO "MIRROR" ALTITUDE
  - OTHERWISE, ANY DESIRABLE REPEAT ORBIT NEARBY?
    - FOR GIVEN INCLINATION AND RANGE OF SEMIMAJOR AXES, SEVERAL REPEAT CYCLE CHOICES EXIST
      - SHORTER REPEAT CYCLES HAVE LARGER ALTITUDE GAPS FROM ONE TO THE NEXT, SO BASIC REPEAT PERIOD IS NEARLY FIXED BY GIVEN <sup>a</sup>

## AEROBRAKING TERMINATION AT HIGH ALTITUDE

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- DECISION FLOW (continued)
  - LOCAL TIME CHANGES
    - IF NOT IN SUN SYNCHRONOUS ORBIT, LOCAL TIME WILL VARY BY UP TO ONE HOUR PER MONTH. FOR FIXED  $a$  AND  $i$ , "LOCAL TIME RATE" IS FIXED
    - MAY BE IN VICINITY OF AN ORBIT WHERE PERIAPSIS LOCATION RATE AND LOCAL TIME RATE ARE DESIRABLE MULTIPLES OF ONE ANOTHER
      - $ha$  OF 12525 KM GIVES EQUAL RATES IN SUN AND PERIAPSIS POSITION, THOUGH  $Q$  IS NEARLY 3.0
      - $ha$  OF 7527 KM GIVES PERIAPSIS RATE DOUBLE THE SUN RATE -  $Q$  IS 4.65
  - ECLIPSE VS. NADIR GEOMETRY, POWER CONSIDERATIONS
    - SHOULD BE EXAMINED, THOUGH NOT MUCH CAN BE DONE TO CHANGE ADVERSE GEOMETRIES
    - ALLOWED SOLAR ARRAY OFF-SUN TIME DEPENDS ON POWER USED PER ORBIT, BATTERY CAPACITY, AVAILABLE ON-SUN TIME FOR BATTERY RECHARGING\*
    - IF LOCAL TIME IS BEYOND SOLAR ARRAY GIMBAL LIMITS, SPACECRAFT MUST SLEW OFF-SUN DURING NADIR POINTING

\*Wayne Lee, "Mapping Operations in Alternate Orbits", 5/15/96

## AEROBRAKING STOPPED NEAR 2 P.M.

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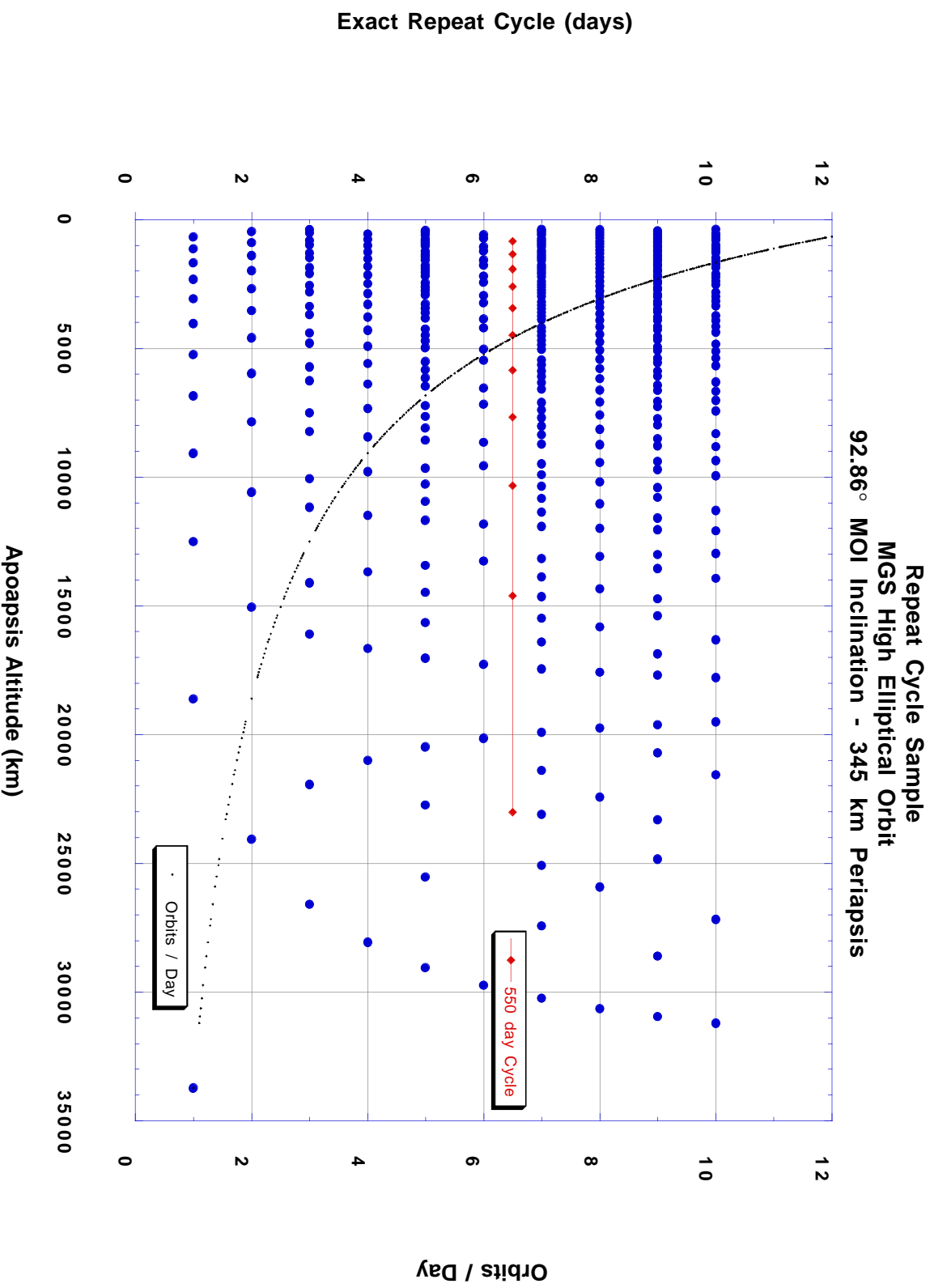
- ASSUME DELAYS IN AEROBRAKING WOULD PUSH FINAL NODE TIME BEYOND 1 P.M. SOLAR ARRAY LIMIT UNLESS TERMINATED EARLY
  - ADVANCE WARNING, ALLOWING TIME TO EXPLORE ORBIT OPTIONS
    - HAVE A TRADE SPACE TO USE - APOAPSIS ALTITUDE VS. LOCAL TIME
- DECISION FLOW
  - EVALUATE DESIGN POINTS ON AEROBRAKING PROFILE
    - TERMINATING ON A GIVEN DATE YIELDS SEMIMAJOR AXIS AND LOCAL TIME (OR, DESIRED SEMIMAJOR AXIS GIVES DATE AND LOCAL TIME)
    - COMPARE GROUND TRACK CHARACTERISTICS, POWER SITUATION, OPERATIONS FOR EACH CASE
  - SUN-SYNCHRONOUS ORBIT FEASIBLE?
    - HIGHER ALTITUDE -> MORE  $\Delta V$  REQUIRED
  - REPEAT ORBITS?
    - MORE FREEDOM TO CHOOSE THAN FOR TERMINATION CASE

## WHAT'S NEXT

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- FUTURE WORK
  - EARLY END OF AEROBRAKING DUE TO LOCAL TIME CONSTRAINT PROVIDES MORE TRADE-OFFS, TIME FOR DECISION-MAKING - WOULD BE WISE TO EXPLORE THIS CASE IN MORE DETAIL
  - TERMINATION DUE TO A SERIOUS PROBLEM OFFERS LIMITED OPTIONS. FURTHER STUDY PROBABLY NOT AS FRUITFUL
- INSTRUMENT PLANS USEFUL
  - IF AND HOW INSTRUMENTS WOULD OPERATE AT HIGH ALTITUDES

# REPEAT CYCLE VS. ALTITUDE





## OTHER FIGURES STILL TO DO...

- E.G. TIME BELOW 500 KM -> SWATH LENGTH
- E.G. SUN RATE, PERI RATE
- LOCAL TIME
- ?

